

## Lab-on-a-Chip Technology for Portable Medical Diagnostics

### RapiD<sub>x</sub> — Rapid, Automated, Point-of-Care System

The rapid, automated, point-of-care system (RapiD<sub>x</sub>) developed by Sandia National Laboratories is redefining possibilities for rapid, point-of-care analyses of health and disease status.

#### The Need for RapiD<sub>x</sub>

Protein signatures of infection, disease, or exposure to toxic substances circulate in blood and saliva. Detecting these signatures before symptoms appear is key for early intervention, which is typically less expensive and more effective than treatment at later stages.

Built on Sandia's advancements in lab-on-a-chip technologies, RapiD<sub>x</sub> is a miniaturized device that requires mere microliters of a sample to measure protein signatures. With RapiD<sub>x</sub>, drawing tubes of blood is no longer required. Instead, drops of blood or saliva can be collected and analyzed at the point of care (e.g., in a doctor's or dentist's office), enabling low-cost, rapid diagnoses during an office visit.

RapiD<sub>x</sub> can also be used to address bioterrorism threats. If a crowd is exposed to dangerous biotoxins, potentially



Sandia's RapiD<sub>x</sub> can analyze drops of blood or saliva in a doctor's office, enabling low-cost, rapid diagnoses during an office visit.

exposed persons can be rapidly triaged with RapiD<sub>x</sub> for timely treatment—critical in such an event—while conserving valuable health resources (e.g., hospital beds, prophylactic supplies).

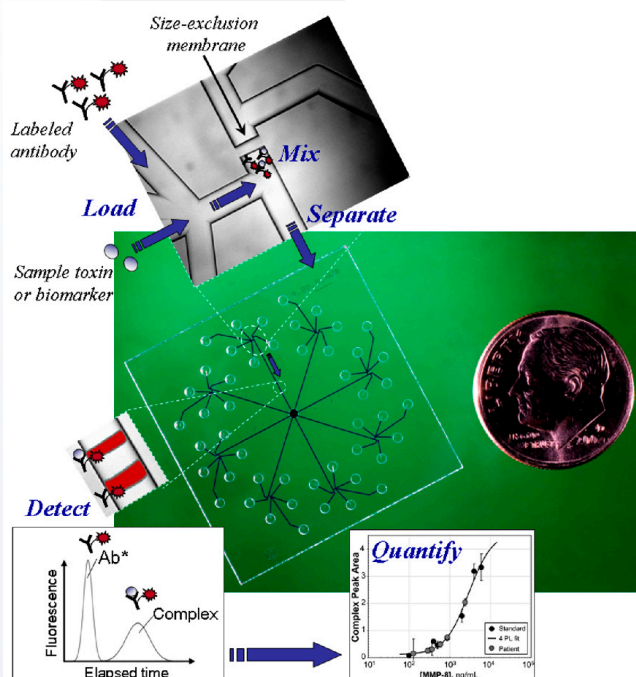
#### Key Advantages

RapiD<sub>x</sub> processes and detects protein signatures by conducting each sample-processing and -analysis step within a microfluidic chip. Our integrated approach is based on highly specific, electrokinetic immunoassays and offers the following key advantages:

- Fast analysis of fluid samples (5–10 minutes), with rapid mixing and separations on-chip, making clinical or field measurements realistic.
- Sensitive quantitation of protein signatures by trapping them at nanoporous size-exclusion membranes.
- Fully automated analysis—including sample-preparation steps and diagnostic tests—through lab-on-a-chip technology.
- Analysis of multiple disease/exposure indicators simultaneously with a single multiplex chip.

#### A Vision Realized

In the past, researchers envisioned miniaturized diagnostic technologies that could accurately ascertain disease state by using



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droplets of human body fluid. RapiD<sub>x</sub> realizes this vision as a lab-on-a-chip instrument that can perform multiple operations in parallel outside the laboratory, such as in field deployment, near-patient environments, and resource-poor settings. In addition, RapiD<sub>x</sub> offers the following operating specifications, which are optimal for point-of-care instrumentation:

- **Microfluidic.** Only microliter volumes (e.g., a small droplet of saliva or blood) are required for analysis.
- **Easy sample collection.** Designed for use with saliva or a pinprick of blood.
- **Multiplex.** A panel of up to 64 analytes can be analyzed simultaneously for accurate assessment.
- **Rapid.** A full panel of analytes is measured within 10 minutes, allowing time for results during a routine clinical visit.
- **Sensitive.** Low-abundance markers and trace amounts of deadly toxins can be detected by sample preconcentration.
- **Wide, dynamic range.** RapiD<sub>x</sub> is adjustable over several orders of magnitude by timing each preconcentration step.
- **Portable and easy to use.** RapiD<sub>x</sub> offers automated, point-of-care testing with a simple touch-screen interface.
- **Low cost.** RapiD<sub>x</sub> makes widespread screening, diagnosis, and monitoring feasible.
- **Versatile.** A variety of diseases, infections, and intoxications can be diagnosed by switching antibody probes.

## Versatile Applications of RapiD<sub>x</sub>

Sandia's RapiD<sub>x</sub> project has demonstrated the potential for portable diagnostics to impact healthcare and homeland security by facilitating early detection, intervention, and



A project funded by the National Institute of Allergy and Infectious Diseases is studying the use of RapiD<sub>x</sub> to rapidly screen individuals for biotoxin exposure.

monitoring of disease or intoxication. Our device directly impacts a number of critical areas of national concern.

- **Disease detection.** A Sandia project funded by the National Institute of Dental and Craniofacial Research used the RapiD<sub>x</sub> microfluidic platform to analyze clinical samples and detect a collagenase enzyme associated with periodontal disease. Unlike the traditional approach—which uses invasive techniques—RapiD<sub>x</sub> has the potential to diagnose patients with periodontal disease at the first signs of microscopic bone loss, enabling treatment before significant damage occurs. The highly versatile RapiD<sub>x</sub> can also be used to detect biomarkers that may be presymptomatic indicators of disease, such as cancer or cardiovascular disease.

- **Ultrasensitive research tools.**

The microsystems developed for RapiD<sub>x</sub> are a step towards fulfilling fundamental needs for highly specific, ultrasensitive, high-throughput, low-cost analytical tools that will not only improve our understanding of host response to infection and illness, but also aid researchers engaged in drug discovery, biomarker verification, and new strategies for therapy.

- **National defense.** Troop readiness and field medical diagnosis and treatment are top priorities in national defense. RapiD<sub>x</sub> allows rapid, simple, and comprehensive diagnostics at low cost at a clinic or in the field. The device also enables quick and effective triaging in the event of intentional crowd exposure to biotoxins, thus improving the outcome for victims and enabling better use of healthcare resources. A Toxin Diagnostics Project, currently funded by the National Institute of Allergy and Infectious Diseases, is using RapiD<sub>x</sub> to rapidly screen individuals for exposure to a number of biotoxins. RapiD<sub>x</sub> provides direct detection of toxins, as well as the signature proteins that are elicited in response to toxin exposure.

## For More Information

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